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Report

D4.2.1 University-enterprise forums and catalogue of challenges

CC WATER

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1 Background for the University-Industrial Collaboration (UIC)

Rapid technological advancements, the rise of new fields such as data technology, external factors as climate change impacts and population growth with globalization and heightened competition, are now seen as key drivers shaping the world economy. Economists are increasingly focused on the critical link between technology and the economy, recognizing technological change as a major factor in economic growth. While labor and capital investments were once viewed as the primary contributors to economic growth, today's economists emphasize technological capability and knowledge as core assets for companies. Some suggest that we are entering a new "knowledge-based economy," where knowledge has overtaken capital as the most vital economic resource (Lundvall, 1994).

In this fiercely competitive and rapidly changing global economy, a company's ability to learn and innovate has become crucial for long-term survival. This understanding has sparked significant interest in technological innovation from politicians, researchers, and industry leaders alike. Scholars across various disciplines have been examining science, technology, and their interrelationship. The traditional "linear" model of innovation, which emphasized radical product innovation and the central role of scientific discoveries in driving technological progress, has evolved. A more nuanced view now sees innovation as a complex process of interaction and learning, replacing the older notion of scientific advancement as the sole driver of technological change. On the other hand, universities are viewed by many as institutions that should impart quality education to enrolled students and foster a learning environment, which, in turn, would benefit the distribution and accumulation of knowledge worldwide. Enhancing university education is at the top of most governmental agendas.

In this knowledge-driven economy, every nation wants to have the world's top-ranked universities. Every parent wants to send their child to a top university. And most people want to have a good university degree that gives them good prospects for landing a respectable job. But universities are currently facing challenges due to increased competition and reduction of enrollments. Once revered as ivory towers of learning, today’s universities are forced to regard their students as consumers and customers. Many universities are now torn between market forces and increasing public expectations and accountability. Universities struggle with declining funding and increased cost scrutiny. Challenged on multiple fronts, universities are faced with conflicting agendas. They are expected to develop world-class reputations in research (an academic agenda) while teaching increasing numbers of students (a commercial agenda). They are required to be engines of economic development while maintaining comprehensive scholarly profiles.

Thus, both the industry and universities see the synergies in collaboration with each other. While countries like US have over century long traditions in collaboration, the most other universities rapidly embrace the concept. This collaboration is also driven by the public policies, legislative frameworks and national, regional and global policies also to collaborate with the governments.

The Triple Helix model was originally proposed by Etzkowitz and Leydesdorff (1995) to explain the dynamic interactions between academia, industry and government for fostering entrepreneurship, innovation and economic growth in a knowledge-based economy (Etzkowitz and Leydesdorff 2000). Since then, the Triple Helix model has quickly become a popular concept in innovation studies. At the same time, its explanatory power has been challenged by some sceptics (see examples in Cai and Etzkowitz 2020), particularly after the development of the Quadruple Helix model, which incorporates public or civil society as the fourth helix, by Carayannis and Campbell (2009). They also proposed the Quintuple Helix by adding a fifth helix—the natural environments of society. The Quintuple Helix addresses the socio-ecological transition of society and economy in the twenty-first century, bringing an ecologically sensitive perspective to the discussion of innovation and knowledge production.

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2 Potential benefits in University-Industry collaboration

University-Industry R&D collaboration (UIC) project is a temporary organization with a collaborative work environment, with heterogeneous partners who have collective responsibilities, and seek to grant benefits to their different stakeholders. Barbosa et al (2023) presented reflection on what these benefits are, and, through a systematic literature review developed a catalog of these benefits in the specific context of UIC projects. From a comprehensive review over 50 publications were studied which identified 45 benefits of UIC projects were identified with varying frequency values, such as 'Patents', 'Publications' and 'New Knowledge Creation'. The collection of benefits was then divided into three categories – Outputs, Outcomes, and Impacts – where it was found that the number of Outputs mentioned in literature was residual when compared to the identified Outcomes and Impacts, highlighting that the benefits of UIC projects go much further beyond the direct Outputs of the project.

2.1 Categories according to the type of benefits

The UIC project benefits can be categorized into five classes: benefit type; benefit nature; benefit perpetuity; benefit agent; and benefit scope (Andrade et al, 2016). These are described in the following paragraphs.

Benefit type

- Strategic: for industry perspective, these are the most important as they correlate the project objectives with organization strategy;
- Operational: these directly influence the daily activities of an organization by changing its nature and possibly improving it;
- Economic: benefits that impact market value assets and resources regulation;
- Social: perceived as the knowledge transfer between university, industry, and also society, it can be identified as social capital.

Benefit nature

- Tangible: benefits measurable in a quantifiable, objective way, e.g. creation of products and processes;
- Intangible: only valued in subjective terms, they are, for example, related to the improvement of innovation capabilities;

Benefit perpetuity

- Long term: outcomes are only perceived to be achieved after the project lifecycle;
- Short term: benefits that cause immediate effects and that can be realized even before the end of the project lifecycle;

Benefit agent

- University: these are benefits that mainly or solely impact university stakeholders;
- Industry: these are benefits that mainly or solely impact industry stakeholders;
- Society: Social benefits can also be obtained at the regional and national levels, such as the generation of jobs, the development of new products or the training of human resources, all of which contribute to improving the economy;

Benefit scope

- Value creation: relates to every benefit that is deemed as a net positive value (which in fact could be, at first, a broader term that encompasses all benefits) as such focus on those that are non-fungible;
- Strategy: those that are in line with the organization strategy and contribute directly to the Key Performance Indicators (KPIs);
- Resource: those related to tangible assets or goods that are used as a result of the project;

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- Quality/performance: the improvements achieved regarding the functional aspects of products and services by improving their capabilities/competencies and the actual or perceived quality;
- Employability: benefits that contribute to or are directly responsible for the creation or maintenance of jobs;
- Knowledge: benefits directly or indirectly responsible for the improvement of knowledge transfer and absorption capacity;
- Inter-relational: these will mostly be indirect benefits related to triggering informal relationships between stakeholders.

2.2 Categories according to the outputs, outcomes and impacts

Another possible categorization is to group the benefits into outputs, outcomes, and impacts. This categorization is integrated into most of the UIC generalized frameworks, however there is no consensus on how to classify them. Based on the framework ultimately developed, which breaks down the UIC project lifecycle into four stages: inputs, in-process activities, outputs, and finally impact, Plewa et al. (2015) furthered the development of the framework that led to the collaboration perspective subdivision of outputs as more tangible and direct or 'hard' results and outcomes, and less tangible ones, with 'softer' collaboration effects, coming possibly later on time. Galan-Muros and Davey (2017), based on the proposal from Plewa et al. (2015), rearranged the definition for the UIC activities results as follows:

- Outputs: are the direct products, services, or other properties, which are delivered as a result of the UIC project. They are typically tangible and countable and are delivered to individual and institutional stakeholders in the short term, for example, a scientific publication or patent.

- Outcomes: are the direct benefits or detriments of the UIC project by individuals and institutions. UIC outcomes derive from outputs, their effects might be perceived as positive or negative for the stakeholder, they also can be tangible or intangible and be experienced directly or indirectly over a wide time range. For example, gaining access to equipment or resources.

- Impacts: are the UIC results experienced indirectly by individuals, institutions, and societies, thus the directness of the effect is the main difference with outcomes. For example, it could be the increase in organization and individual reputation or status.

For the classification of the benefits found, Barbosa et al (2023) noted that a minor change should be made to the above definition of impact. From literature, it was established that this definition refers to indirect experiences, but there are also contradictory definitions that consider impacts as the change that can be credibly attributed to an intervention, an effect of an intervention, or contribution of an intervention that results in UIC agents receiving indirect impacts from UIC in the medium to long term, including individuals, institutions, and societies (EC, 2018). Therefore, impact on this study is understood as an indirect or unintended benefit or detriment that affects stakeholders (irrelevant from their degree of influence or how they are affected), which may or may not contribute to broader project objectives.

3 Barriers and facilitators of University-Industry collaboration

Cooperation in research, development and innovation (RD&I) between universities and industries plays a fundamental role in the economic development of a country. Industry benefits from state-of-the-art laboratories and technologies from academia, while institutes learn about business reality and market needs. Rossoni et al (2023) presented a systematic review on numerous barriers to the establishment and maintenance of partnerships. The facilitators are also identified and were categorized as internal and external. The analysis

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highlights the importance of fostering relational social capital and providing tax incentives to facilitate industry's pursuit of innovation through academia partnerships, and also show that collaborative barriers in RD&I may be overcome to some extent by starting with smaller projects and gradually increasing their complexity.

3.1 Examples of barriers for University-Industrial collaboration

Comprehensive

- Cultural Distinct social, cultural and economic roles that generate a lack of mutual understanding
- Institutional Differences in rules and values, lack of cooperation structure
- Operational Lack of experience, resources, conflicts of interest regarding intellectual property rights, research time-line, etc

Detailed

- Misalignment Lack of alignment between what is done in academia and what is needed in industry
- Motivation Lack of incentive for university scientists and lack of confidence of industrial researchers in academia
- Capability Lack of skills and structure necessary for cooperation
- Governance Lack of management, decision, support and communication
- Contextual Regional characteristics, risk, distances and passive environment

Dualistic

- Orientation Divergent goals and lack of mutual understanding
- Transaction Additional costs, bureaucracy, rules and regulations

Comprehensive: Cultural Detailed: Misalignment Dualistic: Orientation (*read below headings same way*)

- Differences in objectives between the parties. University research is highly oriented towards pure science. Differences between research and enterprise environments. Low level of application of RD&I production to companies' activities. Disparity between university knowledge and the demands of companies. Failure to recognize business value
- Differences in positions and time options between the industry and academia. Industry delays the dissemination of research results
- Lack of mutual understanding about expectations/priorities

Cultural Capability Orientation

- Inequitable interactions and low initial social investment. Research institutes prefer to work alone
- Cultural Contextual Orientation Low level of knowledge about the benefits that can arise from cooperative interactions. Poor attitude towards the partner. Perception that acedemia is not sufficiently competent for cooperation. Perception of academic status and capabilities
- Cultural Contextual Transaction Perception that intellectual property is not important in the particular research field

Cultural Misalignment Orientation

- The research is not linked to industrial interests/needs. Leave of absence of the researcher in relation to the
- activities of the industry

Cultural Misalignment Transaction Universities need publications

- Potential conflicts with industry regarding patents

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Cultural Governance Orientation
- Collaboration with people from different organizations

Cultural Motivation Orientation
- University researchers are not motivated to cooperate.
- Absence of incentives and working conditions. Absence of mechanisms to encourage cooperation
- Collaboration is detrimental to career progress
- Collaborations conflict with teaching/research duties

Institutional Capability Transaction
- Lack of planning and infrastructure
- Absence or low profile of technology transfer offices in universities. Absence of mediators

Institutional Contextual Orientation
- Ignorance of legislation and mechanisms for financing
- innovation and university-industry relations
- Lack of appropriate policies to integrate knowledge-related activities

Institutional Contextual Transaction
- Inconsistent support from political leaders
- Socioeconomic reality (tax, legislation and the cost of doing business in the country)
- Difficulty in finding innovative companies
- Lack of government funding. Lack of financial resources in general
- Professional research networks include few or no companies

Institutional Misalignment Transaction
- Industrial liaison offices tend to exaggerate the results of research or to have unrealistic expectations

Institutional Governance Orientation
- Lack of appropriate mechanisms of communication and collaboration

Institutional Governance Transaction
- Bureaucracy
- Perception of business risks
- High staff turnover and poor industrial strategy
- Lack of established procedures in the university for collaboration
- Rules set by universities or government funding schemes

Institutional Motivation Transaction
- Difficulty of finding partners at universities

Operational Capability Orientation
- Difficulty of contacting individuals in the industry

Operational Capability Transaction
- Lack of preparation of company personnel

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Operational Misalignment Orientation
- Insufficient face-to-face contact

Operational Governance Orientation
- High levels of formality in conversations

Operational Governance Transaction
- Quality of managerial leadership

Operational Motivation Orientation
- Lack of autonomy to work with the industry

3.2 Examples of facilitators of University-Industrial collaboration

Internal
- Organizational structure and technological capacity
- Development of course programs that include student internships and industrial visits
- Organization of seminars and workshops for industrial employees
- Efficient communication tools
- Provision of background information about partners
- Dissemination of knowledge and the results of projects developed in partnership
- Setting up meeting places and creative working methods. Creation of dedicated university-industry interaction offices. Intensive interpersonal interactions and mutual learning as the project progresses
- Adoption of informal management styles that give partners autonomy over decisions
- Understanding the value of the project
- Cognitive social capital
- Intellectual property and technology transfer policies
- Internal technology-based relationships

External
- Construction of social relationships. Development of trust and social connections
- Building trust between partners through a strong leadership (relational dimension)
- Assistance of intermediate organizations in knowledge/technology transfer processes. Stimulation of cooperation through the creation of technology parks and business incubators. Establishment of industry liaison offices (ILOs)
- Geographic proximity between university and the company
- Governmental incentives (programs, legislation and tax exemptions)
- Invitations to industry speakers from the university
- Involvement in university committees
- Mechanisms to connect universities with industries
- Promotion of joint projects through research funding agencies. Financial support from the governmental
- Encouragement and mediation of research and innovation by government bodies
- Provision of funding by external partners
- Combination of different types of knowledge and skills
- Development of mutual understanding

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- Understanding partner and community values
- Trust built on past experience and reputation
- Demonstration of a genuine interest in the success of the partner

4 Approaches to facilitate university-industrial collaborations

4.1 How to build long-term collaborations between universities and industries

In the last decade, there has been an explosion in the number of research deals between companies and universities. Companies, which have been reducing their spending on early stage research for three decades, have been increasingly turning to universities to perform that role, seeking access to the best scientific and engineering minds in specific domains. And faced with stingier government support of academic research and calls for them to contribute more to their local economies, universities have been more receptive.
Instead of one-off projects, both sides have become much more interested in planning for long-term, collaborative relationships. But both sides face familiar obstacles, especially when it comes to navigating non-disclosure agreements and creating a flexible but constructive master research agreement that accounts for potential intellectual property (IP).
Kenneth R. Lutchen in Harward Business Review (2018) noted that neither the university or the industry wants a transactional model that requires a negotiation every time another research project is being considered. Instead, they want a relationship model – a durable, cooperative model that enables companies to partner with academia in a fashion that allows them to stay continuously connected to early-stage research and to accelerate the translation of that research into new products that drive economic growth. He noted below approaches:
Locate the company's R&D near the talent. The advantages of having an R&D presence in industry clusters near major research universities are well known. During the last two decades, the movement to such places has greatly accelerated as companies acknowledged the importance of being where the action is. Fr example, giants such as Facebook, Twitter, and Amazon have established East Coast headquarters or opened engineering and R&D offices in the area, joining Google, IBM, Schlumberger, Microsoft, Comcast, and Oracle, among others.

Seed early-stage research. Instead of just monitoring early-stage research at universities and pouncing when something of interest happens to emerge, smart companies increasingly seed it in areas of interest to them. In the past, some large companies ran their own internal post-doctoral programs without any concrete connection to an academic research group or they sponsored PhD students for philanthropic reasons but without getting directly involved in the students' progress.

A more attractive model is emerging: The company funds or co-funds PhD candidates or postdoctoral researchers studying difficult scientific problems or new areas of technology of interest to the company, and its scientists or engineers co-mentor the researchers with faculty members. If something promising emerges, then more funding is forthcoming either directly from the company or via a collaborative proposal to a government agency by the university and the company. Countries like Norway has state funded programs to promote doctorates for employees at industries.

Cultivate institutions, not just individuals. Typically, companies have pursued one-off projects. Now more durable cooperative models are emerging that enable companies to remain connected to institutions in order to foster long-term research relationships on specific projects of interest as they emerge. Negotiating licensing agreements in advance, stipulating that any emergent IP must be converted into a product within a specified period of time, or it would revert to sole ownership by the university. Having ownership within the universities while exclusivity in commercialization allocated to the industries at a nominal royalty is another approach.

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Look beyond the usual suspects. Companies also recognize that top talent is not confined to just a handful of schools. There are many examples of high-end research conducted at small institutions or departments at less known universities, as well as mediocre research done by some departments at well known universities. Industries should be open to evaluate and consider newcomers, and vice versa.
Find common ground on non-disclosure. The way non-disclosure is often approached continues to be a stumbling block to more fruitful cooperation, leading to misunderstandings and suspicion on both sides. Companies understandably want non-disclosure agreements (NDAs) to keep breakthroughs out of the hands of competitors. But agreements may employ general language that appears to restrict faculty members from discussing entire fields with anyone other than company representatives.

Companies must agree to be as specific as possible in meetings with faculty and spell out precisely what information under discussion they consider subject to the confidentiality agreement. That's what a health care company did in reaching an agreement with Boston University recently. The first draft (from the company) wanted the agreement to cover a broad range of general topics.The final agreement stipulated that the company would spell out during each meeting with faculty what was confidential and subject to the agreement.

Develop more-flexible patent licensing. Universities sometimes think that corporations are looking for cut-rate patents, and corporations often feel universities have unrealistic expectations about the commercial value of patents. Universities must recognize that a patent is not a product. Commercialization can be a long, expensive process borne by the company and not all licensed IP eventually gets embodied in a final product. Similarly, companies must recognize that when a product does succeed commercially, universities that contributed to patents used by the product understandably want to be rewarded fairly for their part in it.

Fortunately, understanding is growing on both sides. Models that are resonating include allowing the company to have royalty-free exclusive patent rights and paying the university license royalties or specific lump sums if revenue from the patent exceeds some negotiated threshold.

Renegotiate in good faith. Typically, a company and a university will initially agree to royalty terms for a specific patent and renegotiate the terms once a real product that employs the particular patent as well as many others emerges and its level of success is clear. But such dealings are often contentious. The university may feel the company is lowballing them, and the company may think the university is deluded about the patent's contribution to the success of the product.

Bridge the cultural divide. The distinction between commercial development and early stage research has traditionally been seen as a defining difference between the values of corporate culture and university culture: the bottom line versus advancing knowledge and training the next generation of scientists without regard to profit. In recent years, however, both sides have moved closer together, meeting somewhere in the middle as their missions have evolved.

Increasingly, companies recognize that if they are to attract the best and brightest talent they must create purpose-driven organizations aligned with values like meaningful work and social utility. Similarly, universities see their role extending beyond teaching and pure research to taking on social challenges and contributing to economic growth.

4.2 How universities may work successfully with other partners

Universities are uniquely poised to collaborate with local people and organisations to address societal challenges. While the precise plans that yield meaningful collaborations will vary based on the given community, Alicia Wilson, Johns Hopkins University, (2021) notes seven guiding principles are cornerstone to being able to work successfully with other partner organisations and individuals:

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1) Listen-to follow – Given that there is no shortage of problems in need of solving, priorities must be set. There are many ways a community's priorities could be set, but the most sustainable and impactful way is by listening to those who are most impacted and then preparing to follow their direction. To transform problem-solving from an academic exercise to systemic positive change, it is necessary for a university to be guided by its community and listen with an ear to follow their direction.

2) Prepare to collaborate – Collaboration between a university and local people takes preparation. It is important to note that there are stark differences in the perspectives, resources, and respective powers of the two groups. To ensure that these differences do not divide but rather multiply the chances that societal challenges might be met, both the university and local people need to prepare to acknowledge these differences, by asset framing or defining groups by their aspirations and contributions, and account for disparities in resources, influence and power and move forward to solving problems as partners.

3) Design to learn – Formal and informal learning should be embedded in the design of any meaningful collaboration between a university and local people and organisations. Thoughtful and intentional reflections should be designed, planned and scheduled as a part of the collaborative process at set intervals. It is important for all parties to recognise that the lessons from a collaborative process are best learned in real time and in an honest and thoughtful manner.

4) Plan to iterate – It is often said that plans are made to be changed. At the start of any project, there are naturally many imperfections. One that will persist throughout any collaboration is imperfect knowledge. Both the university and local stakeholders should embrace and pay attention to new information as the project progresses. This newly learned information should not be viewed with disdain, but rather as "problem-solving gold".

5) Invite innovation and an ongoing relationship – As the collaboration progresses and a problem is being addressed, it is important to invite innovation from all parties and engage in such a way that you facilitate relationship-building. Quite often, the winding path of problem-solving may lead to the solving of another problem not anticipated by anyone. Ongoing relationship building and inviting innovation throughout a collaboration will help generate systemic solutions to societal problems.

6) Evaluate progress – Embedded in every great collaboration is a method for evaluation. This should be done in way that allows best practices to be scaled and those things that are not working to be concluded or redesigned rapidly.

7) Share the blueprint – When successful collaborations are forged and progress is made, universities have an obligation to share those practices with others. Universities have the power to convene all segments of society and sharing useful lessons and insight from meaningful collaborations will help spread knowledge needed to address societal challenges within a particular community and beyond.

As stated at the outset, universities are builders but what they build is not a given. Put simply, thoughtful collaborations between universities and local communities provide the critical infrastructure to solve societal challenges in the best way possible, that is, together.

4.3 An example of development of cognitive and relational social capital in the research alliances

Differences in goals and approaches between firms and universities often lead to challenges that prevent the realization of fruitful university–industry collaboration. Steinmo et al (2015) presented a review how the development of cognitive and relational social capital can, over time, mitigate such challenges and encourage fruitful collaboration between firms and universities in research alliances for the development of innovations.

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The study was based on interviews with two UIC alliances. Alliance 1 is a well-established user-driven and mature research alliance established by the firm participants. This alliance has managed to develop knowledge and innovation with university partners through their long-standing collaboration. Alliance 2 is a research-driven research alliance established by a university partner. Compared to Alliance 1, Alliance 2 is an emerging alliance which faces more collaborative challenges. Second, to better understand the social capital development in research alliances, this study draws particularly on insights from six firms: three in each alliance, which is suggested as a suitable number for case studies

Level	Relational social capital	Cognitive social capital
Individual	Firm employees and some of the collaborating universities had been previously acquainted, and they have become familiar with the universities over time	Firm employees has developed individual cognitive social capital over time where the firm representative in the alliance has managed to achieve common understanding towards the collaborators
	"We know the [universities] very well" (Firm 1)	"There has been very good communication and teamwork from the beginning" (Firm 1)
	"Acquaintances are important, as is having personal relationships to rely on" (Firm 2)	"It is not complicated to talk with the researchers. We understand each other. Of course, there are some very specialized people, but they are not the ones who we meet with" (Firm 2)
Firm	The firms within Alliance 1 have developed relational social capital at firm levels through close acquaintances over time. The collaborating firms and universities know one another very well	Some of the firms began with a different understanding of the universities but achieved a better understanding, and it developed shared goals with the universities over time
	"We have close contact with them [the universities]" (Firm 2)	"The cooperation with them [the universities] has worked very well, and good projects and clarifications have come out of it" (Firm 1)
	"We have become closer and more able to communicate in a general way" (Firm 3)	
Alliance	Alliance 1 have developed relational social capital at an alliance level by cohesion and closeness where the firms and the collaborating universities know one another very well	There is common understanding and good communication between the firms and the collaborating universities. Occasionally, goals are mismatched, but that problem is solved through good communication
	"We are like a family" (Firm 2)	"We have to be very clear at an early stage about what we want to achieve with the [universities] to reduce the risk of letting the researchers work on things that they find interesting but that may not be interesting to us. If the working premises are based on their [the universities] interests, it is not good for any of us" (Firm 3)

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Level	Relational social capital	Cognitive social capital
	"Compared with other research partners and collaborations with people who we do not know or have not worked with before, this collaboration functions very well" (Firm 1)	"We have a common goal and are clear on what to examine … All of us are moving in the same direction and set the conditions for the collaboration" (Firm 2)
	"When we need specialized research, we have people who know about our industry and about our challenges" (Firm 3)	"Usually, we have the same goals as the [universities] with respect to the development of the industry, but sometimes we have different long-term goals and strategies to reach those goals. It depends on close interactions with the industry, and we work on projects in accordance with the industry" (Firm 3)
Individual	"We know each other [i.e. the universities] very well, and that makes the collaboration easy" (Firm 3)	
	Some individuals within the firm and the universities are acquainted with each other. Several firm representatives were previously employees of the primary collaborating university	Low level of cognitive social capital at an individual level
	"The trust has always been there; we are used to working with universities, and they are used to working with us" (Firm 5)	"I have an understanding of the [universities'] goals, but I am not sure that they understand our goals … The [universities] have lost contact with the industry" (Firm 4)
	"I know them [the universities] very well and know how the [university] system functions. I have been working there for 15 years" (Firm 4)	Over time, the individuals representing the firms have developed more understanding of the collaboration and thereby built more cognitive social capital
Firm	We don`t know the people (Research partner)	"Understanding has become better during the collaboration" (Firm 5)
	Low level of relational social capital at the firm level)	The firms and universities have had different goals since the beginning of the collaboration. The firms expected the universities to be engaged in what the firm wanted to develop, but the universities were disengaged
	"We have had previous projects with them [the universities]" (Firm 4)	"The [universities] are working to finish publications. That is good because it builds competence, but there is too little industry contact" (Firm 4)
	"There should have been closer contact between the firms and the [universities] within the [research alliance]" (Firm 4)	"We have pushed the [universities] to be more concise when presenting, something that they have improved by getting more 'to the point'" (Firm 5)

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Level	Relational social capital	Cognitive social capital
	Over time and after feedback from the industry, the universities have become more involved in engaging the firms in the collaboration	"I don't believe that they don't want to have the same goals as us. It is all about their ability to complete things. That is the case for us, too. It is about time" (Firm 6)
Alliance	"They [the universities] have become much more proactive in involving the industry partners" (Firm 4)	
	Lack of relational social capital at an alliance level. The alliance has not yet managed to develop closeness and cohesion among the collaborators	There are different understandings and poor communication at the beginning of the collaboration. After feedback from the firms, the universities have improved
	"I don't think the [alliance] has been good enough as an alliance. It has been to many separate pieces" (Researcher)	"There is a gap between our goals" (Firm 4)
		"The challenge has been poor communication between us and the [universities]" (Firm 5)

4.4 A framework to improve university–industry collaboration

Collaborative framework It is evident from the review described in the previous section that several 'best practices' have been formulated for successful collaboration. However, these best practices are scattered through the literature, and some authors have focused on only one aspect of collaboration such as technology transfer or problem-solving. Aswathy et al (2020) proposes a generic framework considering several aspects of the variety of interactions possible between universities and industry. They analysed the best practices for successful collaboration described above and derived a framework for improving the effectiveness of UIC. This framework considers a comprehensive list of factors operating in a broad and wide context within the collaboration system. The underlying hypothesis for this framework is that creating an enabling environment will result in more effective collaborations.

(1) Understand the Variety of Interactions– As a starting point, it is very important to understand the various kinds of interactions or relationships that are possible between universities and industry. Different types of interactions have different degrees of involvement and duration, and offer specific benefits. An understandingofthenatureofthoseinteractionswillallowthestakeholderstomake an informed decision about selecting a partnership suitable to the context.

(2) Identify the Stakeholders– Observing the bigger picture of collaboration indicates the presence of several stakeholders. Examples of some stakeholders as universities and basic research institutes (e.g. Max-Planck Gesellschaft in Germany), applied research institutes (e.g. Fraunhofer Gesellschaft in Germany),start-upcompanies,research-basedcompanies(e.g.SiemensCorporate Technology), development-based companies (e.g. Siemens Business Units) and consulting companies. Another study identifies stakeholders in business research as experts and resources, research and teaching, students, organizations and companies, industry and business interests. It is critical for engaging parties to identify a set of strategic partners to collaborate with. While focusing on strategic partnerships, the value of non-strategic partnerships should not be ignored, as they have their own benefits in a particular context. Identifying the stakeholder and the problem to be addressed are intertwined. Thus, they are not sequential and may randomly follow each other.

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(3) Understand the 'Why'–Identify the motivation– Universities and industry have invariably different motivations for collaborating. It varies from problem solving, resource-sharing or information/people access to skills development through education. It is important to identify motivations and common areas before co-working or collaborating. Claus Otto, programme managerat RoyalDutch Shell PLC, says, 'It is important to ask yourself: What can these university centers do better or different than we can?'. This requires due time, discussion and deliberation. If the motivation is problem-solving, stakeholders should select a problem that possesses intellectual rigour and is motivating for both the partners. The problem should complement academic expertise and be relevant to the industry. Universities should also aim at selecting a generalizable problem within the partner organization, as it will have wider applicability leading to greater impact for the organization and the partnership. Such a selection of problem and solving it with a 'consideration of use' is expected to enhance its impact. 'Business needs what the university has to offer because they won't succeed unless they innovate'.

(4) Identify and Appoint Suitable People and Involve Leadership– It is to be noted that characteristics of individuals and an organization influence the level of collaboration. Universities should identify the key university staff and faculty suitable for interactions: '...achieving a high level of collaboration depends on participants who contribute an openness to change, a willingness to cooperate, and a high level of trust'. Young researchers are typically more suitable for identifying the characteristics of the economic environment. Involving and engaging people who cross boundaries have a positive impact on the relationships. The industry should select capable managers for effective project management. Appointing the right people is the key to the success of a collaboration. Universities should take the leadership role while businesses employ their potential in playing with boundaries between organizations, domains and capabilities.

(5) Ensure Basic Partnership Characteristics– For the success of a partnership, it is important to ensure some basic set of principles to work under. Stakeholders should identify a win-win situation and agree upon it and work under an agreed framework, ensure a long-term commitment. Long-term commitment is demonstrated by the level of engagement in the form of people and resources from each stakeholder from the beginning of interaction until the final phase. Extensive university support and industrial personnel participation in establishing the research agenda and reviewing the research progress and results should be ensured. Last but not least, government support and encouragement to collaboration can lead to the formation and success of collaborations.

(6) Establish Efficient Communication–Interpersonal communication is acritical factor in the success of a relationship. Company and university leaders must understand each other. Stakeholders should adopt measures to improve communication between them, such as being in regular contact to meet and talk regularly, engaging with the partner daily (if required) and utilizing various modes of communications such as mobile, digital media and face-to-face talks. Communication and monitoring need to be well implemented for fostering communication, including the follow-through processes. Progress reports should be madeavailable at various stages of collaboration. Communicating the benefits of the collaboration can stimulate future collaborations. Regular access to top management should also be provided for the successful collaboration.

(7) Strengthen the Dissemination Strategy– Universities must work towards strengthening their dissemination strategy and to using elements of marketing for sharing the research results along with their rigour and relevance to attract new partners. They should use a variety of channels to enhance the dissemination of results, leading to improved industrial adoption of research such as increased contact with consumers of knowledge, validating the applicability of research results in a client-centric way and formally creating new positions as knowledge brokers in academia.

(8) Address IP Concerns– It is advisable that the value of a partnership should be seen in terms of other benefits rather than getting hung up on intellectual property (IP). A common understanding must be developed among everyone about intellectual property. Partners should minimize constraints on information, and universities should not seek to overprotect IP to prevent IP from becoming a stumbling block. In some cases,

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stakeholders should agree to drop claims. Establishing shared and enforceable guidelines limiting disclosure restrictions, limiting conflicts of interest and agreeing on a clear IP framework will help in overcoming the legal barriers associated with UICs.

(9) Adopt Policies to Encourage/facilitate Collaboration– Successful collaborations need to be encouraged and supported by policy interventions. Institutions must collaborate to develop a common policy on conflicts of interest for themselves and their faculty. Policies should help in resolving institutional conflicts and filling role gaps at the university–industry interface. Policies must be revised to meet the changing features of the research environment while preserving the academic and financial integrity. Universities should work towards the reduction of the financial/material costs of interaction and long-term development of industrially relevant academic R&D resources. Stakeholders should also participate in the processes of national policy formulation and influence it for increased benefits.

(10) Adopt Strategy to Encourage Collaboration–Successful collaborations, often, are a result of the commitment of the partners shown by making collaboration apart of their strategy. Stakeholders need to listen to each other and seek ways to work together. This is facilitated by developing a clear strategy. A good strategy for collaboration will include deliberate and informed planning, identification of key contracts using environmental scanning, adopting a legal framework for cooperation and proper preparation. Strategies should aim at developing new partnerships and supporting existing projects to launch new opportunities. Research universities need to redefine their role as a source of competence and problem-solving for society.

(11) Focus on Social Capital Resources– Social capital resources include trust, mutual obligations, common understanding, access to information and opportunities. The existence of mutual trust is an important factor leading to effective knowledge sharing between various stakeholders and contributing to the success of the collaborative venture. Individuals demonstrating entrepreneurial skills are believed to foster the network competence of an organization. The network competence refers to the ability of a team to develop and utilize relationships with external stakeholders such as research institutes, industry and government bodies. Network competence significantly influences the effectiveness of collaboration activities.

(12) Setup Rewards and Incentives– Anew system of incentives should be created in universities to recognize the efforts of the academics participating in partnerships with industry. Rewards and incentives are expected to influence the motivations and level of engagement of individuals, leading to more effective collaborations.

(13) Management of the Collaboration– It is important to manage collaborations. Adopting a framework to manage the collaboration process in a similar manner as the software development lifecycle will help in monitoring, course-correction during the collaboration process and achieving the set goals.

(14) Alumni Association– Universities need to maintain connection with their graduating students who would work in industry or become an entrepreneur in future. Connection with those students is an opportunity for university to discuss industry problems and understand ways of working together to solve those relevant problems. These alumni can become mentors for present cohort of students. 'By developing long-term relationships with the university, graduates help the university to re-learn'.

5 University-Industry collaboration within the CC Water consortium

The CC Water project has universities from program countries (Norway, Poland and Germany), and 8 universities from partner countries (China, Mongolia and Sri Lanka). All partners have had collaborations with industrial partners although format, mechanisms, continuity vary.

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For example, UOP (LK) has a decades long relationship with several industrial partners to collaborate in master studies. This may include student placements for shorter or longer periods. QUT (CN) also has a long term partnerships with an utility in Qingdao, which enters into collaborative research agreements to solve prioritized challenges. Both NMBU (NO) and THOWL (DE) also had similar practices with utilities, but also with industrial actors who provide services to the utilities. However, the latter partnerships are time-bound and the content and value vary from task to task.

All partner universities search for collaborations with industrial partners, including end-users, R&D projects funded by various state and private organizations. Both NMBU (NO) and THOWL (DE) extended their student placement and supervision collaborations with industries in a Erasmus+ Knowledge Alliance where they collaborated with two industrial partners.

QUT (CN) and NMBU (NO) had a long term relationships with industrial partners also extending to beyond their own countries. They have initiated industrial collaborations partially funded by their national authorities, with great success in developing innovations with potential for commercialization.

5.1 Examples of University-Industry Collaborations

5.1.1 University of Peradeniya, Sri Lanka

The Faculty of Engineering of the UOP(LK) is dedicated to providing professional expert services to both industry and government through its commercial arm, the Engineering Design Centre (EDC). Faculty members are given the opportunity to serve as resource persons in offering these services and work on multidisciplinary projects that provide invaluable experience in various fields. The Department of Electrical, Electronic and Energy Engineering (DEEE) members are offered projects that allow them to apply their knowledge and skills in Electrical & Electronic Engineering, as well as explore other fields. Additionally, members are encouraged to undertake consultancy work as individuals or groups with written permission from the Vice-Chancellor. With a commitment to excellence, the Faculty of Engineering and its members continue to make a significant impact in the world.

UOP also has established a tradition of holding Annual Industrial Advisory Board (IAB) meetings which are very useful in receiving feedback from industry and employers as they are one of the key stakeholders of the Department and the Faculty. IAB is comprised of multitude of representatives from different industries related to the six sub-specialization areas of DEEE. The IAB meeting minutes are properly maintained and follow-up actions are also presented to IAB and discussed at the next meetings. This provides an opportunity for DEEE to hear the views from the industry on modifications of DEEE curriculum, student performances in the industry and required areas of improvement and any other matter not foreseen by the DEEE.

5.1.2 Rajarata University of Sri Lanka

The University Business Linkage Cell, Rajarata University of Sri Lanka, acts as the industry's gateway to innovations at RUSL. We aim to collaborate with government and private sector industries to commercialize RUSL innovations and inventions of research outcomes, as well as to address issues of the industry to develop the social and economic growth of the country. Also, UBL supports the community by providing Intellectual Property protection assistance.

The establishment of the University Business Linkage (UBL) Cell is a necessary step in implementing the UGC Circular 10/2016 in the Rajarata University of Sri Lanka with the support from the Accelerating Higher Education Expansion and Development (AHEAD) Project. In effect, the UBL Cell functions as the Technology Transfer Office (TTO) of the RUSL.

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Establishing Technology and Innovation Support Centers (TISC) in Sri Lanka is a joint project of World Intellectual Property Organization (WIPO) and National Intellectual Property Office (NIPO) of Sri Lanka. TISC program in the university is designed to give university staff and local inventers easy access to locally based, high quality technology information and related services.
RUSL (LK) have developed several documents and mechanisms to promote UIC: Intellectual Property Policy, Agreement for the Transfer of Materials, Constitution of Business Linkage Cell, Material Transfer Agreement for the Transfer of Organisms (MTA-TO), Mutual Confidentiality Agreement, Intellectual Property Disclosure Form, Patent Licensee Agreements, UBL UGC Circular Guidelines, UBL UGC Circular are some, examples.

5.1.3 South Eastern University of Sri Lanka

SEUSL (LK) has established a University Business Linkage Cell with a vision to be a business linkage centre of excellence in growing your business and implement the University - Industry relationship as to uplift the socio-economic development of Sri Lanka. Their ambition is to actively participate to the human capital development of Sri Lanka through the business consultation programs, research cooperation, training, coaching and workshop that aiming to build the Industry - University relationship between local community and the SEUSL (LK).
They work to promote the growth of local enterprise (local economic development), by fostering linkages between University, Corporate Companies and Public sector. The identified tasks are facilitate compliance for business in respect codes of good practice, establish a business linkage centre that will be sustainable and offer continued service to the business community, develop an extensive data base for local, national and international applications etc.

Further, the UBL Cell is entrusted to undertake following missions: develop and promote common technologies; participate in the establishment of enterprise innovation system; promote university technology transfer and commercialization; strengthen international technical innovation collaboration; and provide various integrated service for enterprises.

5.1.4 Mongolian University of Science and Technology

One example of the UIC at MUST (MN) is the partnership related to Artificial Intelligence for Mining company Strayos. Strayos and MUST are integrating Strayos' AI and Data Analytics solution into MUST's curriculum, assisting in research, and exploration of AI solutions for the mining industry.

For years the mining industry has been looking for ways to attract new talent and to integrate new solutions to increase safety, reduce environmental impact, and remain competitive. This initiative by MUST and Strayos will help students prepare for the industry’s transition to digitalization.

The Strayos CEO, Ravi Sahu noted that this collaboration will both help move the industry forward by educating its newest members on the huge contributions AI can make to this critical industry and also ensure MUST students are prepared for the future of working in mining.

Benefits of the Partnership include: Strayos software will be included in MUST's curriculum, Student and University Licenses to the Strayos platform, Software and AI application trainings, workshops, lectures, and seminars, Industry connections, MUST student internship opportunities, Research and exploration of AI applications for the mining industry.

5.1.5 National University of Mongolia

Rio Tinto, the global mining company that manages the massive Oyu Tolgoi gold and copper mine in the South Gobi, in Mongolia has signed a major agreement with the NUM (MN).

Rio Tinto previously sponsored the university’s first series of addresses from Nobel Prize winners, and worked with the NUM’s School of Economic Studies on a landmark Economic Impact Assessment for Oyu Tolgoi.

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Oyu Tolgoi President and CEO Cameron McRae from Rio Tinto participated in the signing of agreement. This Memorandum of Understanding represents an opportunity to expand the existing relationship between Rio Tinto and the National University of Mongolia.

“Through this MOU, we will help the University build up its teaching and research capacity through a speakers’ series and support education and training of Mongolian's through scholarships, internships and the latest educational resource materials:” stated McRae. “In turn, the University will support public education initiatives to increase public awareness of responsible mining and help train our employees by delivering short-term courses and other activities.”

In addition to the support and cooperation provided to the NUM through Rio Tinto, Oyu Tolgoi has several projects in place which are expanding opportunities for Mongolians in the areas of higher education and vocational training.

Those projects include: An investment of approximately 110 billion MNT that is being invested in training and education over the next five years, creating the largest vocational training programme ever established in Mongolia; Two major universities in Nalaikh and Dalanzadgad; and Five centres which are currently being upgraded across the country.

“Relationships with top universities are very important to Rio Tinto because we are committed to supporting programmes that improve the educational outcomes of people in the communities where we operate:” noted McRae. “This is evident from our regular investments in education and training development.”

5.1.6 Qingdao University of Technology

QUT (CN) has been collaborating with several industrial partners, including both large enterprises which are active throughout in China and the local water utility companies. QUT and Beijing Enterprises Water Group Limited (BEWG) have established a joint teaching/training organization – QUT-BEWG Modern Water College for the training of students’ readiness in the job market. BEWG provides senior engineers to share application examples, pros and cons of emerging technologies with practical experience. BEWG is the largest utility company in Asia operating more than 1000 water and wastewater facilities. Some of the “retired” facilities (plants, pipes, et.al). The retired equipment has been transported to retired plants with empty tanks for demonstration purposes for students. QUT has also cooperated with BEWG and moderated the BEWG National Innovation and Entrepreneurship Contest in 2022.

QUT (CN) encourage teaching and research staffs to undertake the responsibility of local service for industry. Students’ involvements are highly encouraged. The Water Education and Research team at QUT have participated in several types of technical service projects including sponge city designing, evaluation of wastewater treatment process planning, and troubleshooting.

Everbright Environmental Co., Ltd has developed a firm cooperation with QUT by establish a new research institute with investment from both side – QUT-Everbright Environmental Research Institute. This new institutes was established nearby the campus of QUT. MSc and PhD student have the access to work in the laboratory of this institute part time for the analytical need of industrial water and air samples. The company benefits with the high-quality labor of research students, and the university benefits from the access to the recently advanced analysis equipment and analyzed samples and data for further research.

5.1.7 Inner Mongolia University of Finance and Economics

The growing trend of university-industry collaborations that bridge the gap between academic knowledge and practical application, benefiting students, industries, and regional development. Through these partnerships, IMUFE is not only enhancing their educational offerings but also contributing to broader societal and economic goals.

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Strategic collaborations between IMUFE and Xinhua News Agency's Inner Mongolia branch and between the School of Resources and Environmental Economics signed a cooperation agreement with Hoh-hot Borui Land Planning and Design Co., Ltd, are successful examples.

Among the other important activities, the strategic collaboration meetings with Inner Mongolia Financial Investment Group, the Inner Mongolia Traffic Transport Department, the Business Department, and Shandong Hengbang Technology Development Co., Ltd.

Furthering their commitment to regional development, the university's faculty and students conducted a field survey in Kulun Flag from July 24 to 25, 2024. This activity included researching local industries and providing lectures on regional economic issues. The collaboration aimed to identify practical solutions for local development challenges and enhance the university's role in regional economic growth.

5.1.8 Shenzhen Institute of Advance Technologies

As one of china's highest academic and industrial technology research institute, SIAT is committed to propel industrial cooperation in association with well-known technology transfer organizations and enterprises at both domestic and overseas level. Last year, the total contract amount of industrial research and technology transfer that SIAT signed exceeded 250 million RMB, the contracts payment amounted to 100 million RMB. By 2024, SIAT has boasted 853 spinoffs and 365 shareholding enterprises. These enterprises have a strong presence in various sectors, including medical technology, information technology, and new energy. Also, SIAT has fostered long-term partnerships with well-known enterprises such as BMW, Intel, IBM, Huawei, and Tencent, etc.

SIAT aims to build up a need-based platform for high-tech, enterprises, organizations and government, combine their expertise, and offer comprehensive technical method and solutions to industrial partners to help them improve the capability of R&D and innovation. Based on SIAT's research area and expertise, offer industry partner consultancy service for their technical pre-research, the implementation of patent, technical innovation and government policy research. Combine partners' strength and SIAT's resources to help enterprises create niche markets. SIAT's patent and PCT applications rank first among universities and research institutions worldwide, with a transfer and transformation rate of 27.2% and an invention disclosure rate of 72.4%.

Moreover, SIAT provides comprehensive capital support and business counseling resources throughout the stages of business development, from seed to mature stages, leveraging government and institutional support, angel investments, venture capital, and partnerships with major banks.

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